Constellation X

The Constellation X-ray Mission

TRIP Highlights

Jean Grady
Constellation-X Deputy Project Manager
Goddard Space Flight Center

Technology Readiness and Implementation Plan (TRIP) Overview

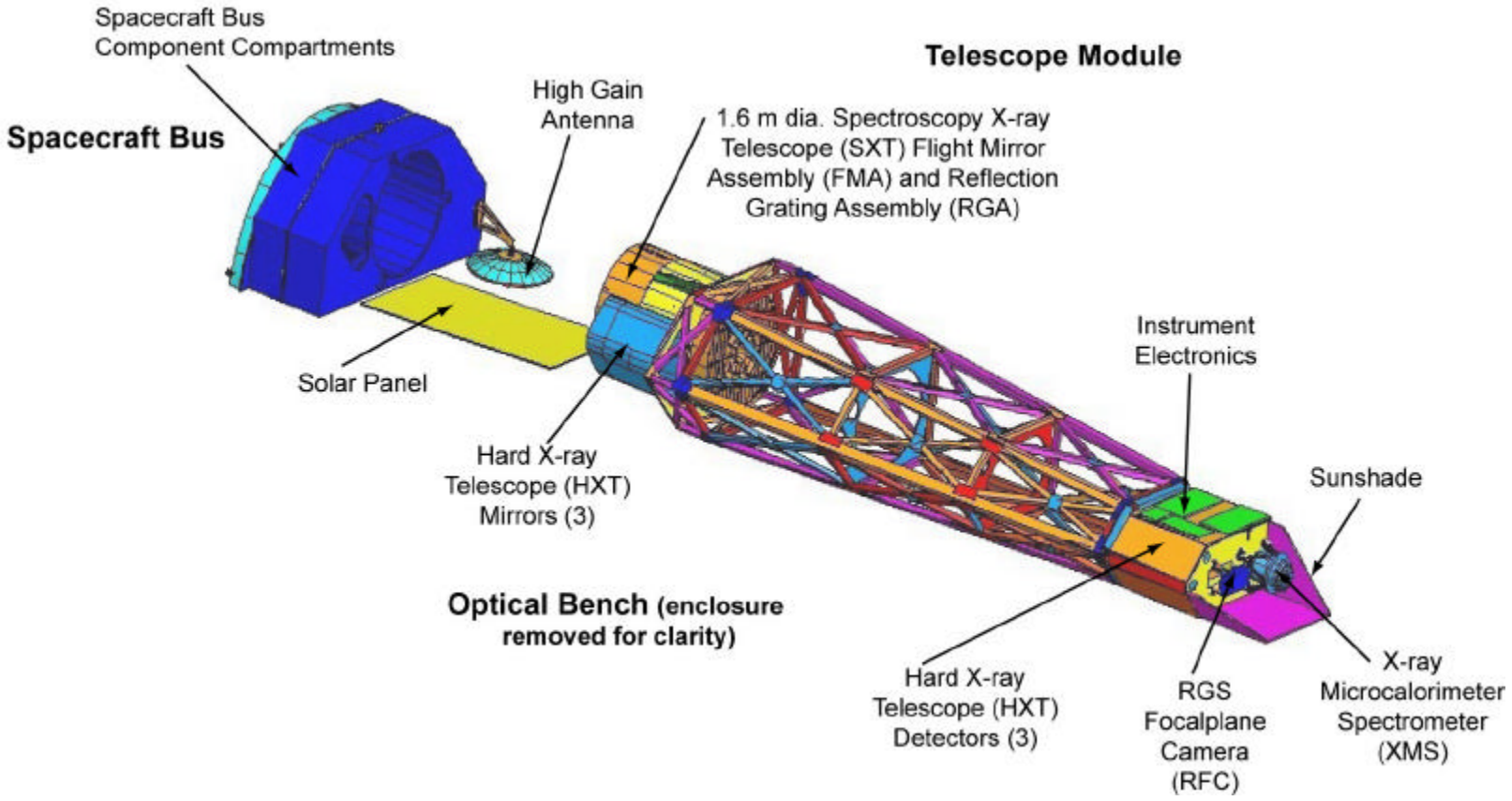
- **Schedule of Events**
  - Received Call for Reports from HQ early October 2002
  - Report provided to HQ on February 3, 2003
  - Received follow-up questions on Feb. 21 and March 5, 2003
  - Held site visit at GSFC on March 20, 2003
  - TRIP Review Report issued April 22, 2003
- **Report Content**
  - Science and Instrumentation description
  - Mission Implementation
  - Technology Development Plans
  - Management and Costs
- **TRIP Report available on the Constellation-X Project Library Web site**
  - http://conxproject.gsfc.nasa.gov/engn.htm

Many thanks to all who contributed to the Constellation-X TRIP Report and to the TRIP site visit!

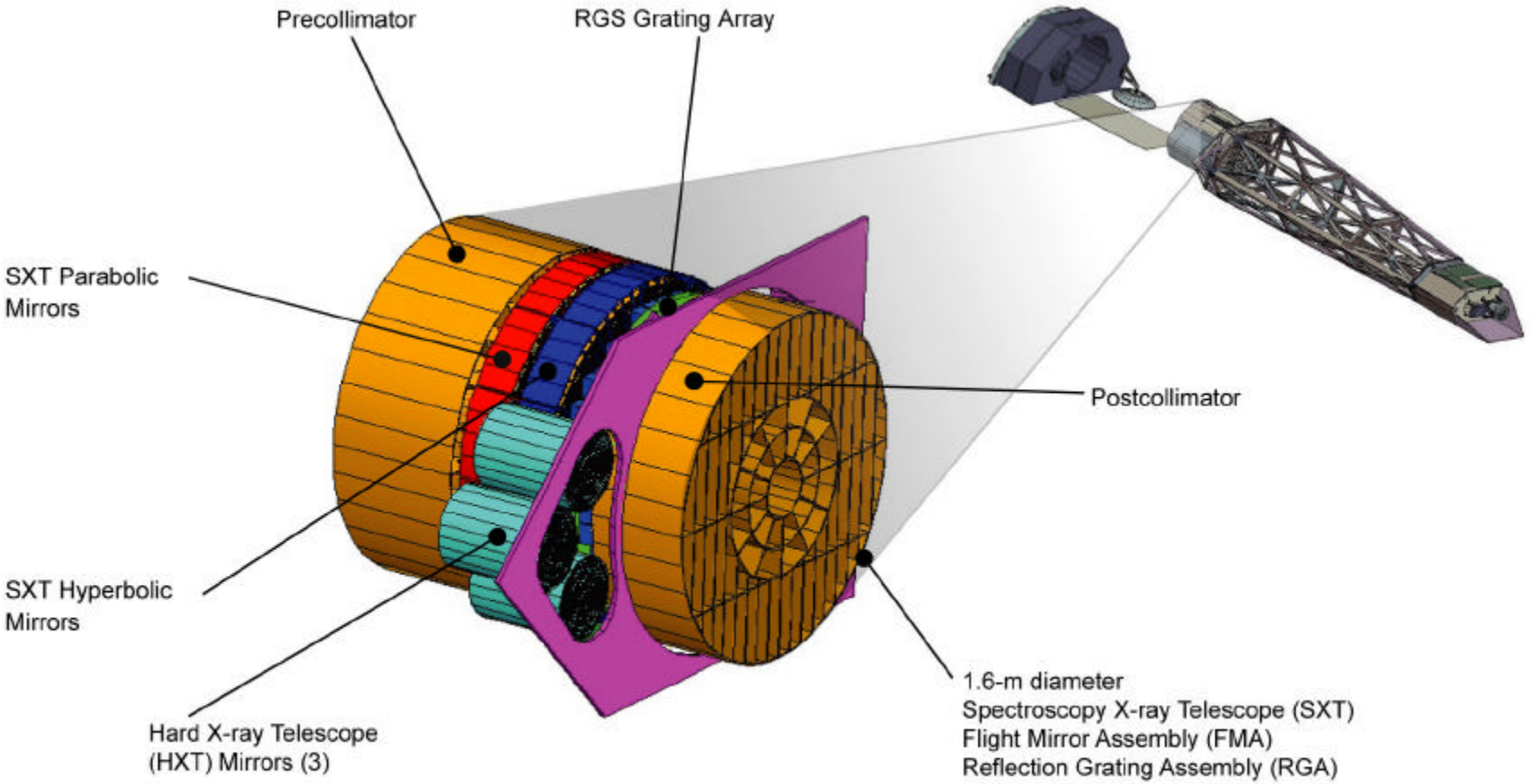
Reference Mission Configuration

- Overall Reference Mission definition remains unchanged
  - 4 identical observatories, 2 observatories per launch, L2 orbit, etc.
- Refined modular concept for Reference Mission Configuration
  - Telescope Module, consisting of
    - Optics Module (OM)
    - Optical Bench (OB)
    - Focal Plane Module (FPM)
  - Spacecraft Bus
- Refined instrument and spacecraft block diagrams and conceptual designs
- Updated power and mass budgets
- Developed I&T flow, which takes advantage of modular design to minimize schedule and risk
- Refined Missions Operations Concept

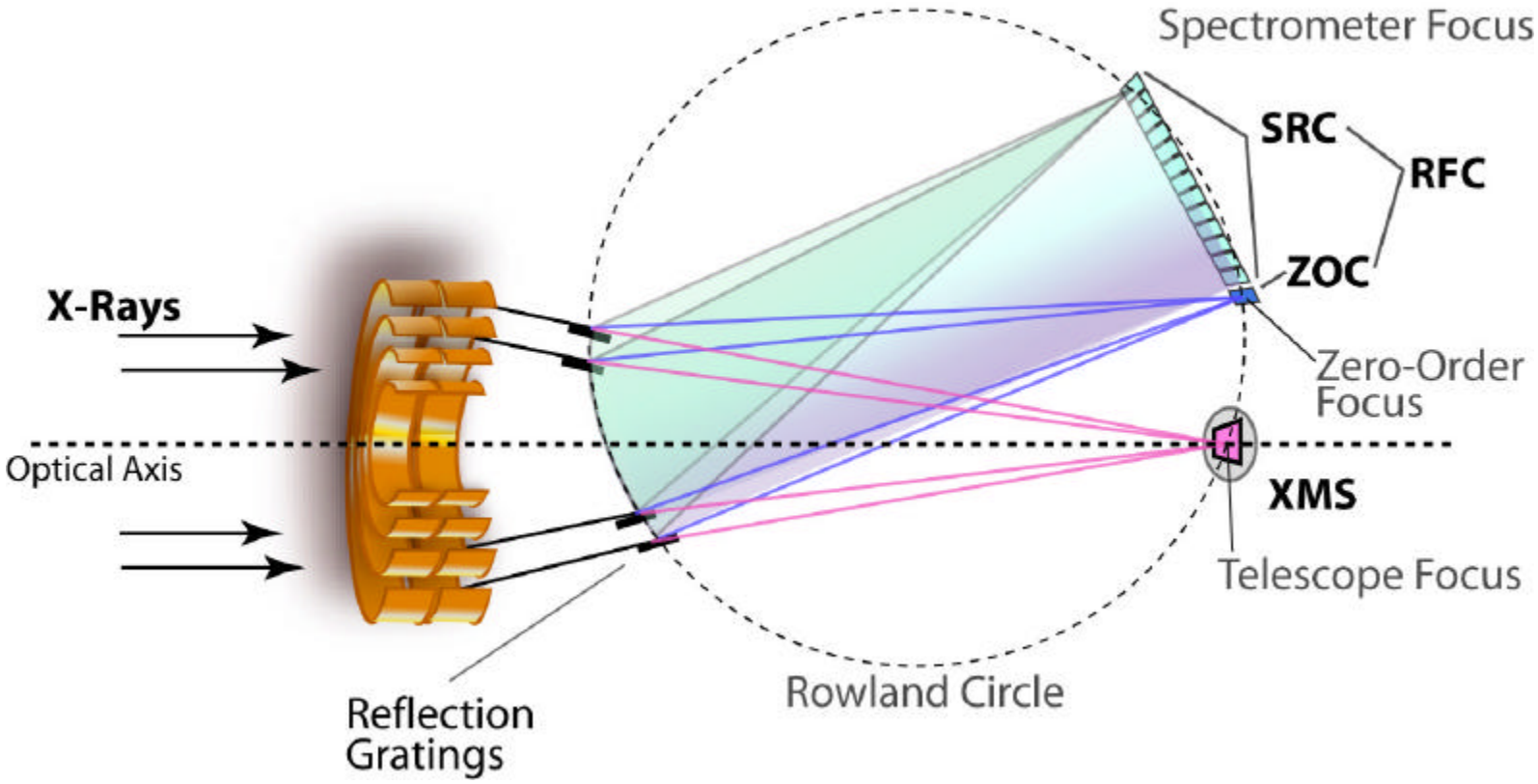
Exploded View of Constellation-X Observatory



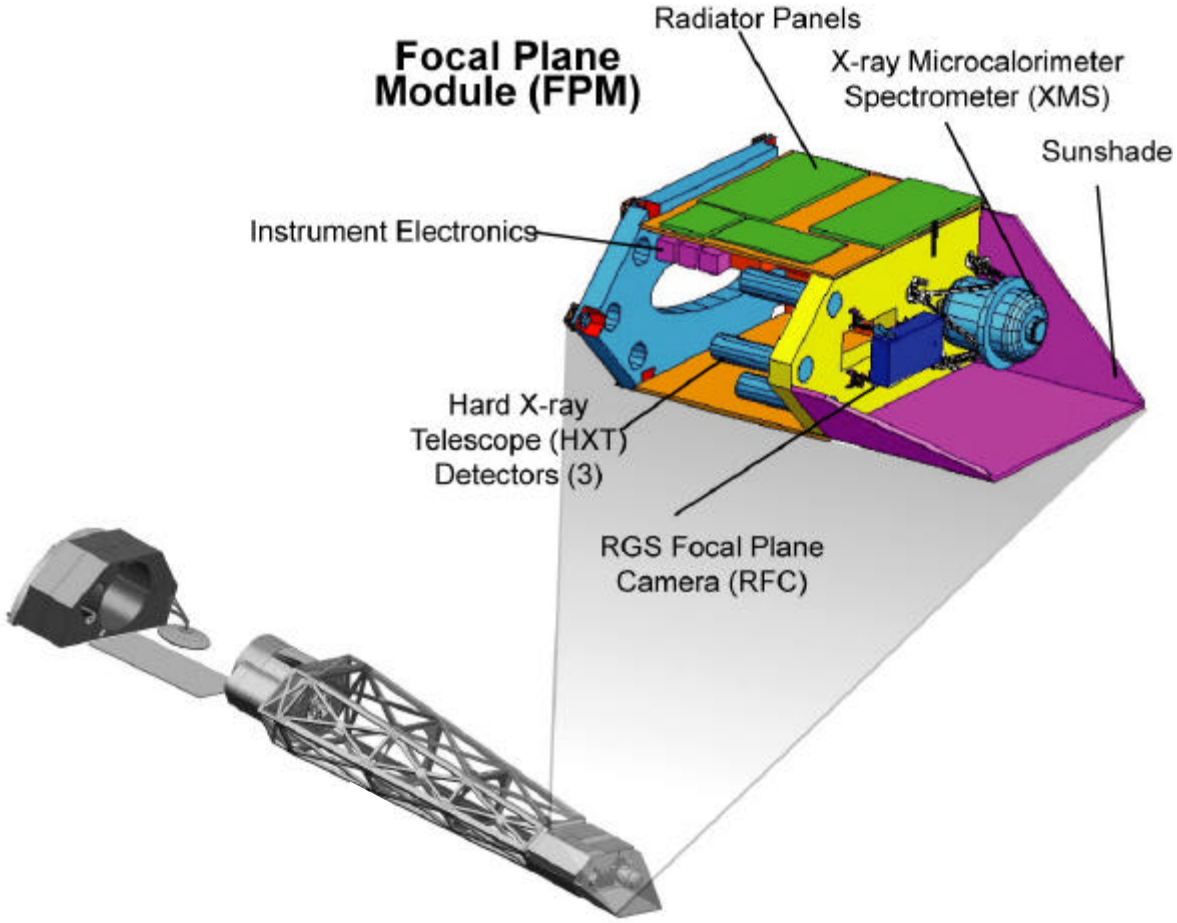
Constellation-X Observatory — Optics Module



SXT Optical Path



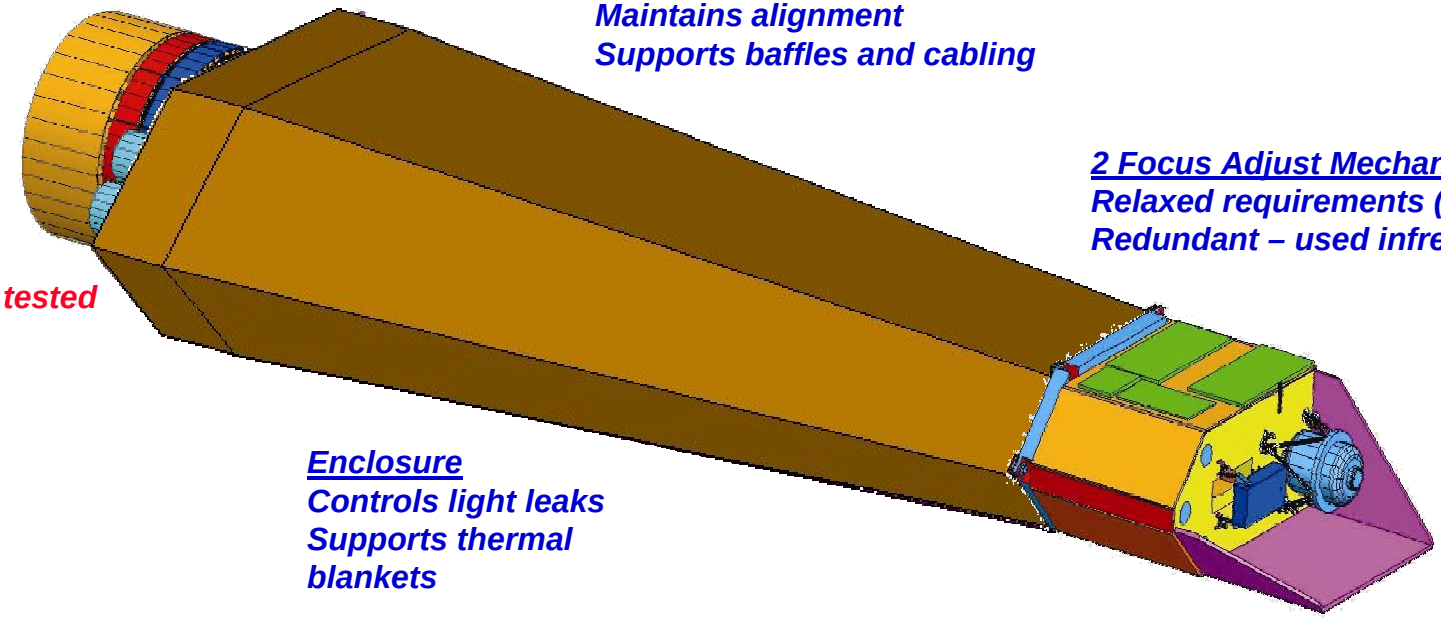
Constellation-X Observatory — Focal Plane Module



Telescope Module (TM) — Organization

2 Protective Covers/Mechanisms
Outer Protective cover (on bus)
Inner Protective cover (not shown)
Redundant drives – used one time

Optical Bench
Establishes gross focal length
Maintains alignment
Supports baffles and cabling



2 Focus Adjust Mechanisms
Relaxed requirements (1 mm)
Redundant – used infrequently

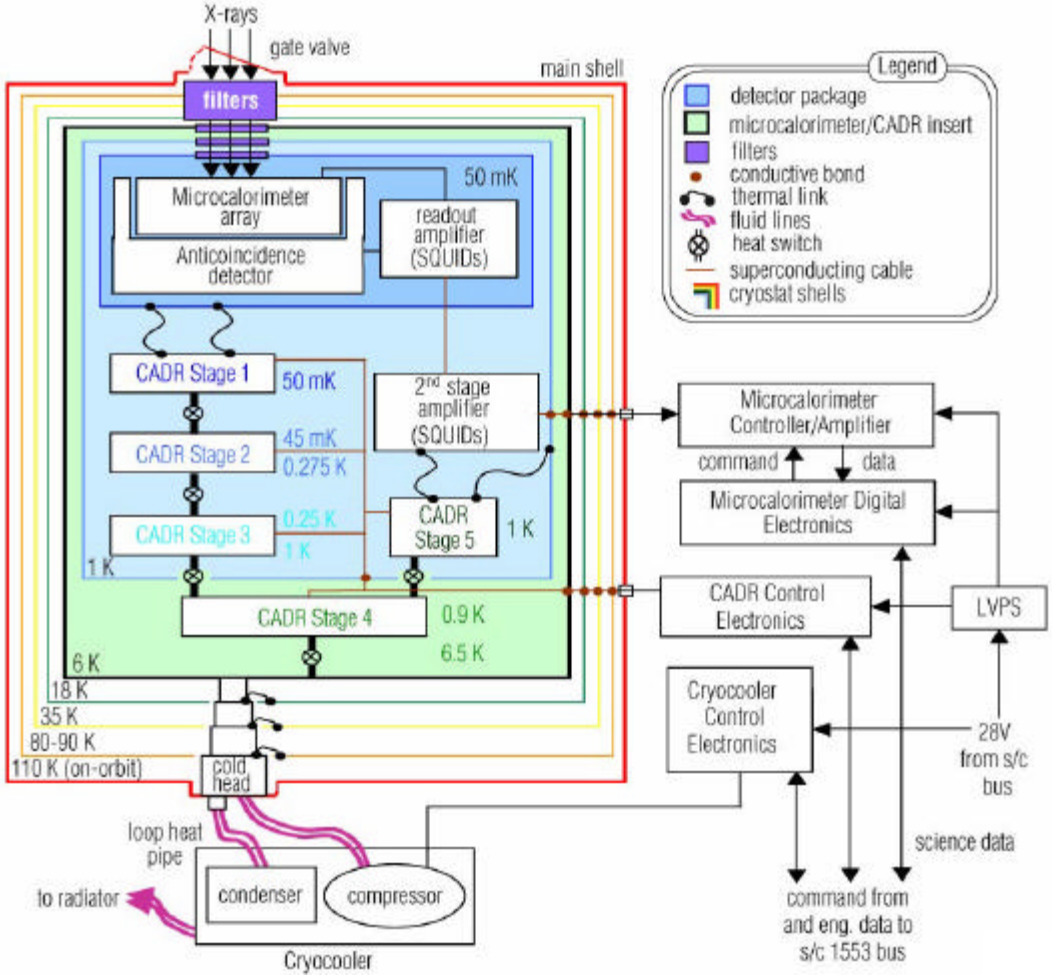
Optics Module
(integrated and tested separately)

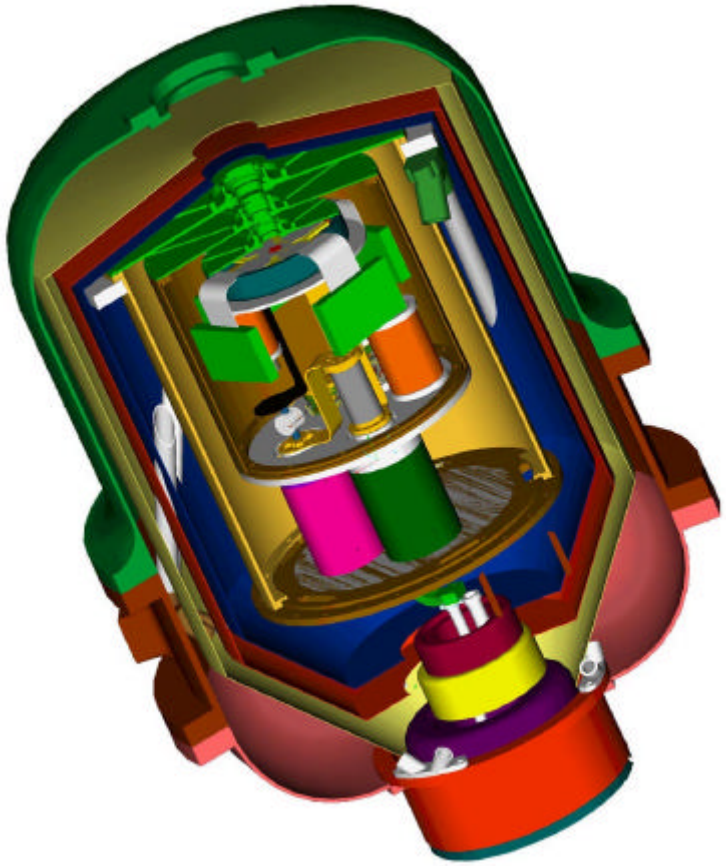
Enclosure
Controls light leaks
Supports thermal blankets

Calibration Source Blocker Mechanism

Focal Plane Module
(integrated and tested separately)

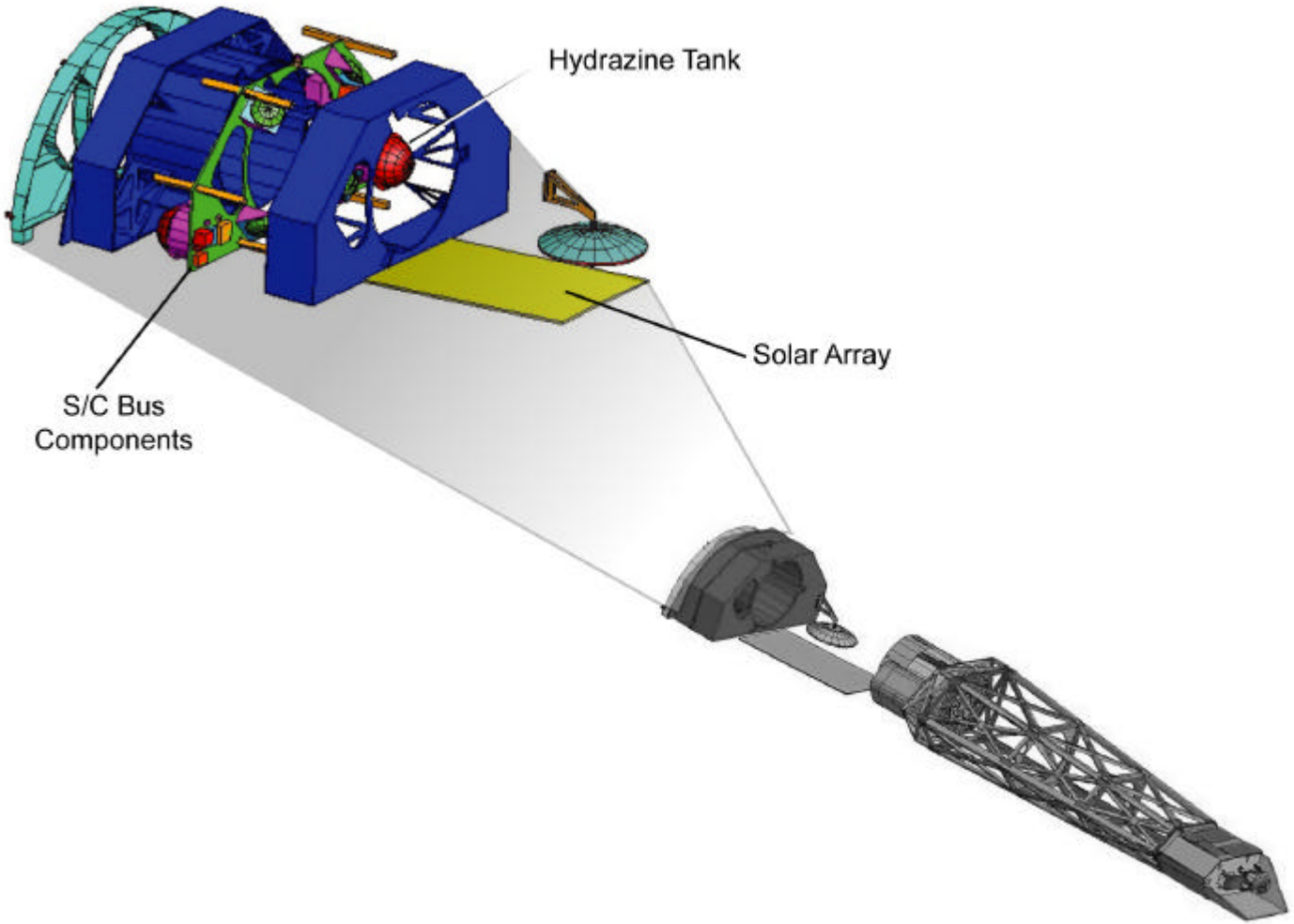
X-ray Microcalorimeter Spectrometer (XMS) Block Diagram and Conceptual Implementation





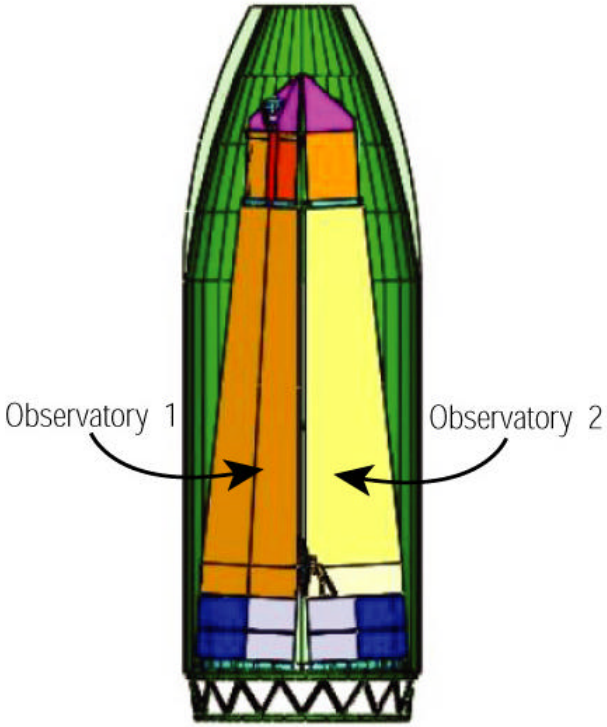
Size ~ 50 x 75 cm
Mass ~ 150 kg, including electronics

Constellation-X Observatory — Spacecraft



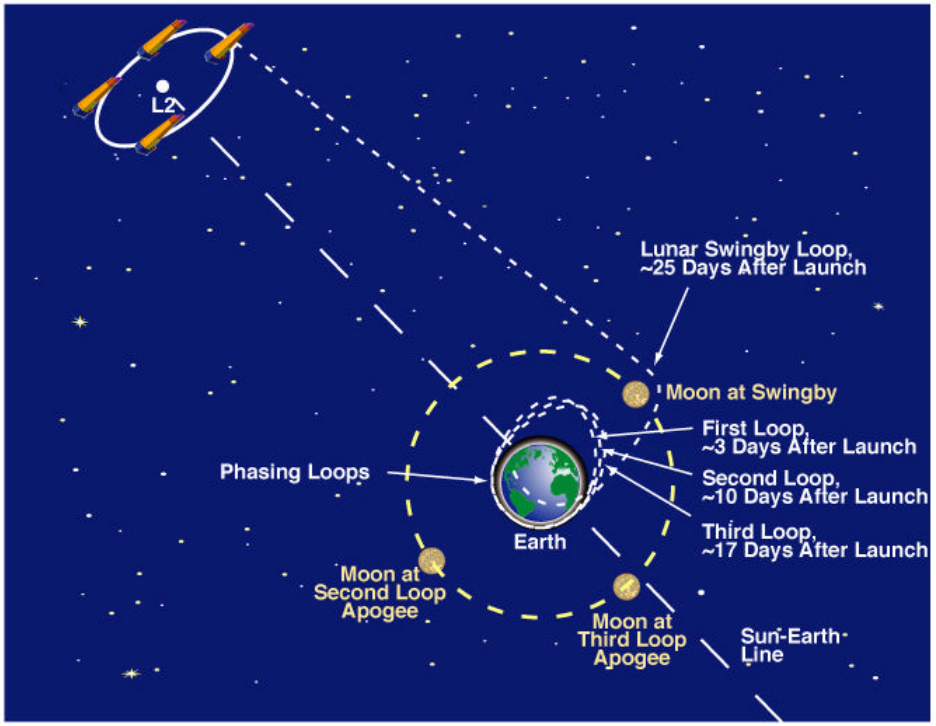
Constellation-X Launch Configuration and Orbit

Constellation-X Launch Configuration



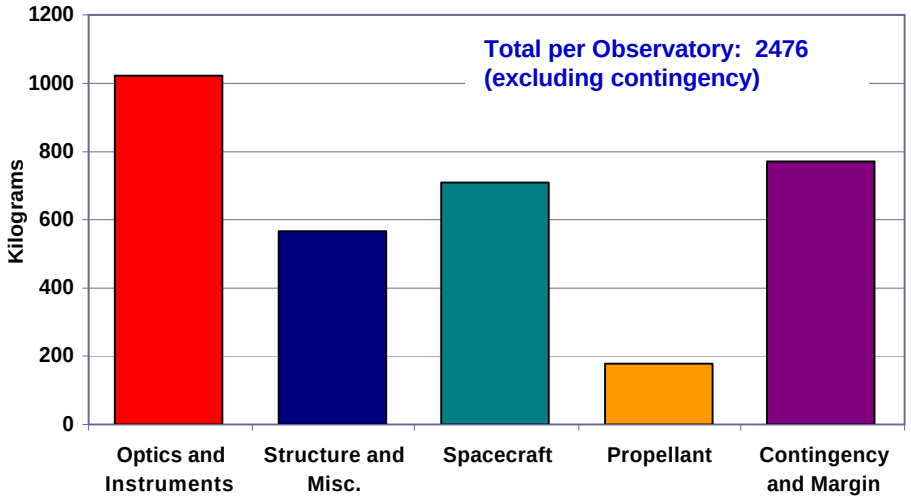
ATLAS V

Trajectory with Phasing Loops and Lunar Swingby



Mass and Power Resources

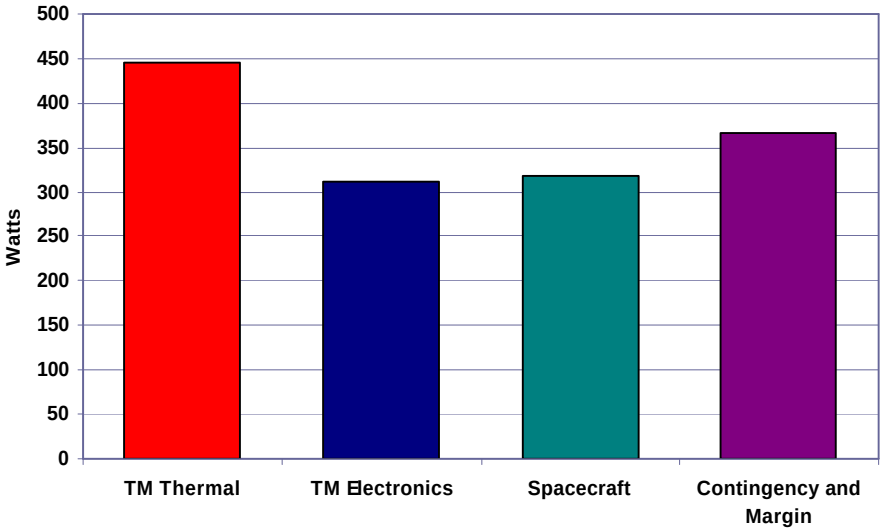
LV Performance = 6498 Kg



% Contingency & Margin = 34%

Mass

Solar Array EOL = 1442 W

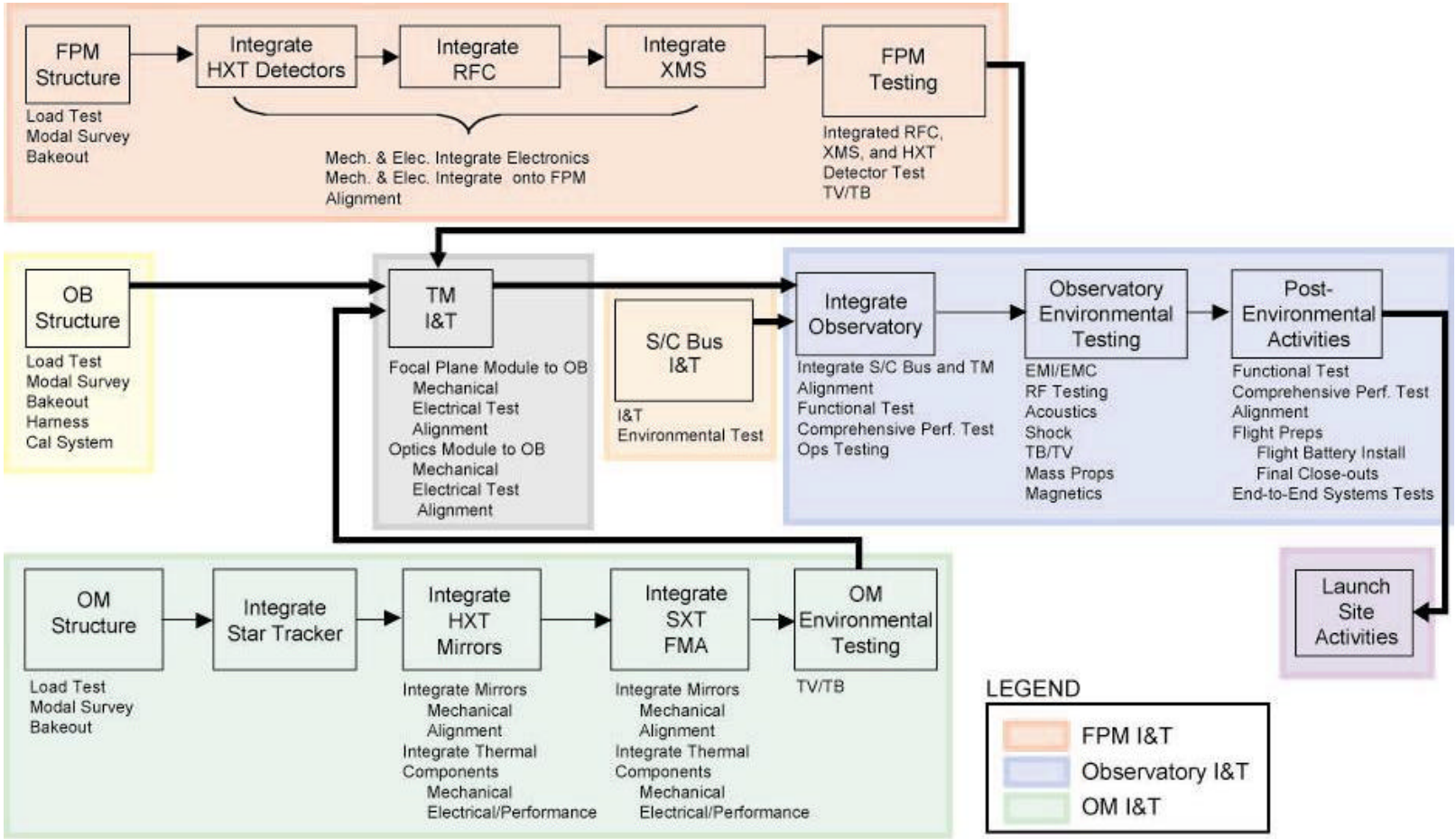


% Contingency & Margin = 34%

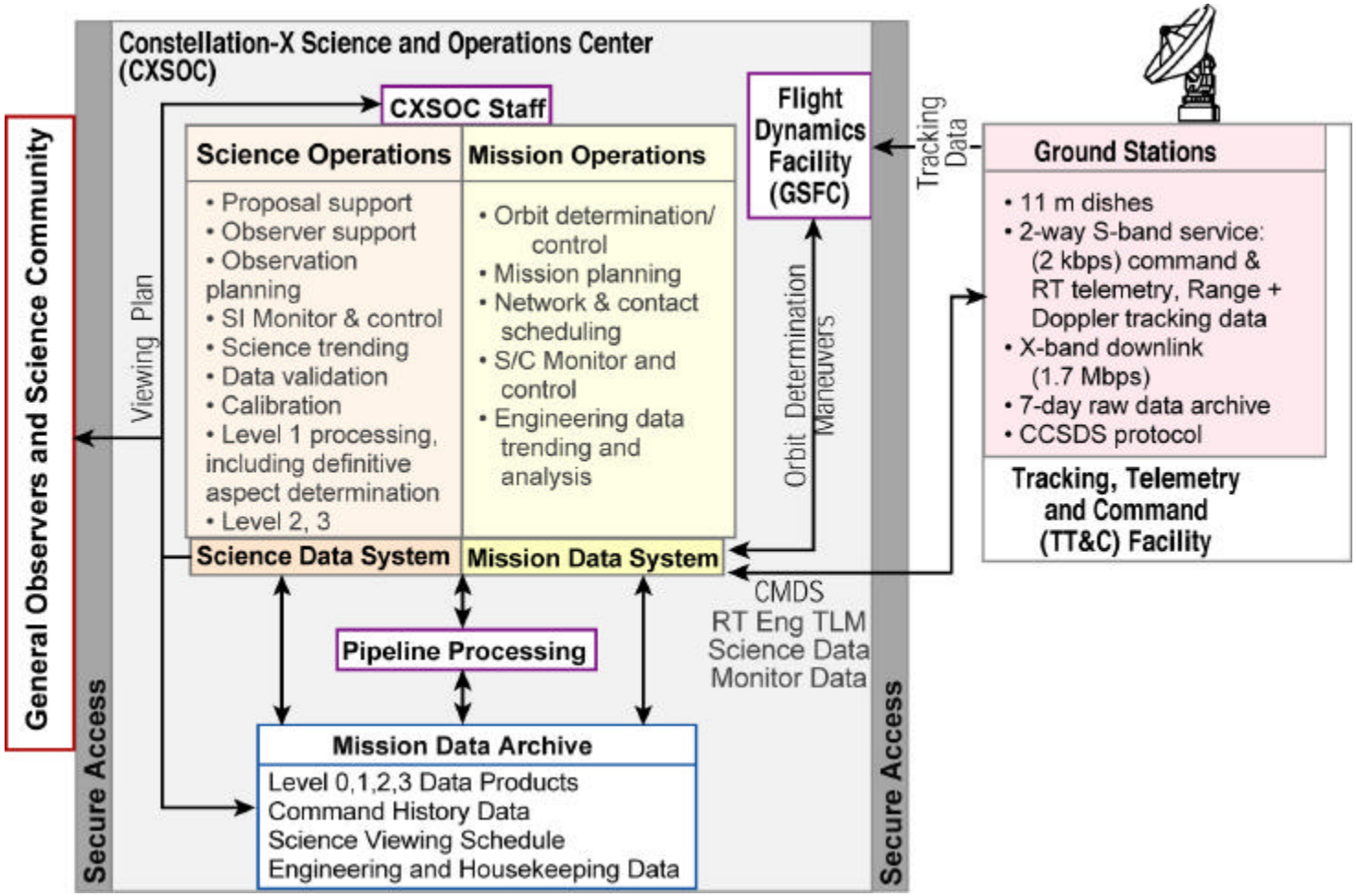
Power

- Sufficient resources are available for the mission

I&T Flow


FPM Structure
Load Test
Modal Survey
Bakeout
Integrate HXT Detectors
Integrate RFC
Integrate XMS
Mech. & Elec. Integrate Electronics
Mech. & Elec. Integrate onto FPM
Alignment
FPM Testing
Integrated RFC, XMS, and HXT Detector Test
TV/TB
OB Structure
Load Test
Modal Survey
Bakeout
Harness
Cal System
TM I&T
Focal Plane Module to OB
Mechanical
Electrical Test
Alignment
Optics Module to OB
Mechanical
Electrical Test
Alignment
S/C Bus I&T
I&T
Environmental Test
Integrate Observatory
Integrate S/C Bus and TM
Alignment
Functional Test
Comprehensive Perf. Test
Ops Testing
Observatory Environmental Testing
EMI/EMC
RF Testing
Acoustics
Shock
TB/TV
Mass Props
Magnetics
Post-Environmental Activities
Functional Test
Comprehensive Perf. Test
Alignment
Flight Preps
Flight Battery Install
Final Close-outs
End-to-End Systems Tests
Launch Site Activities
OM Structure
Load Test
Modal Survey
Bakeout
Integrate Star Tracker
Integrate HXT Mirrors
Integrate Mirrors
Mechanical
Alignment
Integrate Thermal Components
Mechanical
Electrical/Performance
Integrate SXT FMA
Integrate Mirrors
Mechanical
Alignment
Integrate Thermal Components
Mechanical
Electrical/Performance
OM Environmental Testing
TV/TB
LEGEND
FPM I&T
Observatory I&T
OM I&T

Constellation-X Mission Operations



Requirements and Error Budgets

- **Mission Top Level Requirements remain stable**
  - **Incorporated Spectral Resolving Power of 1500 from 6 to 10 keV**
- **Updated Mission and Instrument error budgets**
- **Documented flow down of requirements to each instrument and instrument elements**

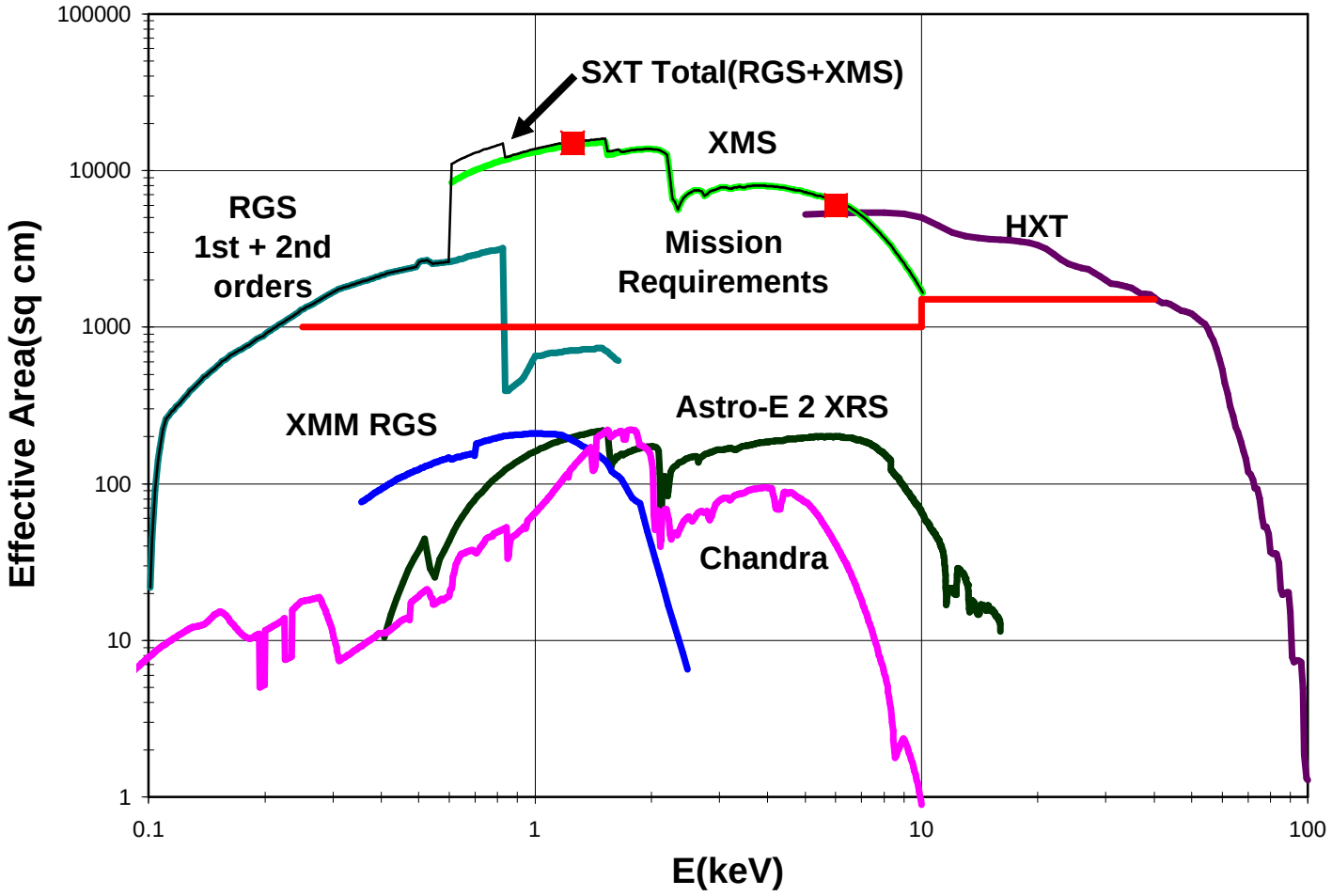
Key Top Level Requirements

Parameter	Baseline Requirement
Bandpass	0.25 to 40 keV
Effective Area	
0.25 to 10 keV	1,000 cm^2
1.25 keV	15,000 cm^2
6.0 keV	6,000 cm^2
10 to 40 keV	1,500 cm^2
Spectral Resolving Power (E/DE)	
0.25 to 6.0 keV	300
6 to 10 keV	1,500
10 to 40 keV	10
Angular Resolution (HPD)	
<10 keV	15 arcsec
>10 keV	1 arcmin
Fields of View	
<10 keV	2.5 arcmin
>10 keV	8 arcmin
Bright Source Limit	40,000 cps
Absolute Timing (relative to UTC)	100 microsec
Mission Lifetime	4 years at full capacity

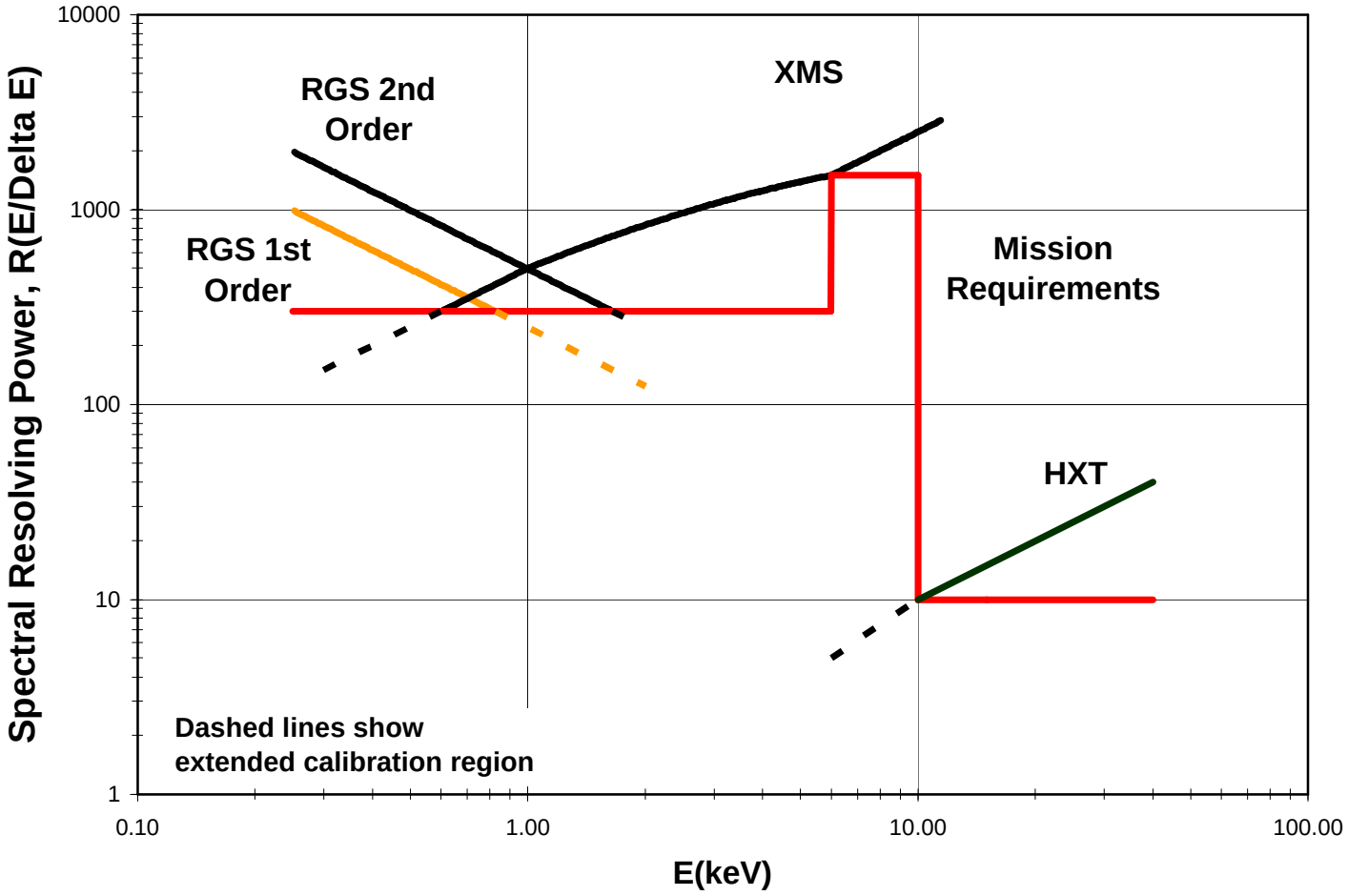
SXT Effective Area Budget

SXT Effective Area Budget				
	Area At Energy			
	0.25 keV	1.25 keV	6keV	Comment
SXT FMA Geometric Area	59,400	59,400	59,400	230 shell design
Reflectivity loss	-17,118	-18,641	-50,324	Gold coating
SXT FMA Effective Area	42,282	40,759	9,076	9076 was 8709 in TRIP (error)
SXT Effective Area Losses				
Structural blockage	-5,919	-5,747	-1,534	Baseline housing design
P-H Shell Alignment	-423	-611	-182	1% loss
Aperture Alignment	-211	-306	-91	1/2% to 1% loss (energy dependent)
SXT Contamination - EOL	-423	-408	-91	1% (Chandra experience)
SXT Effective Area	35,306	33,687	7,179	
(per SXT)	8,826	8,422	1,795	
XMS Area Feed	19,627	18,826	6,109	
RGS Area Feed	15,678	14,861	1,070	
Instrument/Telescope losses				
RGS Internal Vignetting	-784	-743	-54	
XMS(Cal QE, Filter, fill factor)	-19,627	-3,212	-410	
RGS(Grat Effy, CCD QE, Filter)	-12,659	-13,280	0	
Grating internal alignment	-157	-149	-11	1%
Off-axis operation	-14	-172	-68	Raytrace
Inst Contamination - EOL	-784	-941	-14	0.2% to 5% energy dependent
Total Area - Predicted	1,281	15,191	6,622	
Total Area - Requirement	1,000	15,000	6,000	
Margin(%)	28.1	1.3	10.4	

Mission Effective Area



Mission Spectral Resolving Power



SXT Angular Resolution Error Budget

Item (HPD – arcsec)	Rqmt	Margin	Allocation/Predictions					Rationale
RGS Resolution	15.00	4.01	14.46					4 satellites, post-processed
Co-add 4 satellites				1.00				Superposition of data using X-ray centroids
On-Orbit Telescope - single satellite				14.42				RSS
CCD pixelization error					0.41			0.5 arcsec pixels
▪ Grating resolution errors					5.00			Estimate
XMS Resolution	15.00	4.95	14.16					4 satellites, post-processed
Co-add 4 satellites				1.00				Superposition of data using X-ray centroids
On-Orbit Telescope - single satellite				14.12				RSS
▪ Calorimeter pixelization error					4.08			5 arcsec pixels
▪ Telescope level effects					5.20			RSS
– Image reconstruction errors (over obs)						4.24		RSS
– SXT/Telescope mounting strain						2.00		Eng. estimate based on Chandra experience
– SXT/SI vibration effects						2.00		Chandra experience (jitter)
– SXT/SI misalignment (off-axis error)						1.00		Chandra experience
– SXT/SI focus error						0.20		Analysis
▪ SXT Optics - on-orbit performance					12.48			RSS
– SXT Mirror launch shifts						2.00		Eng. est. based on Chandra
– Thermal errors						2.24		RSS
– Material stability effects						1.00		Est. based on Chandra work
– SXT Mirror, as built						12.07		RSS
➢ Gravity release							1.50	FEA analysis using vertical assy
➢ Bonding strain							3.00	Eng. estimate, analysis in process
➢ Alignment errors (using CDA)							3.38	RSS
➢ Installation in housing							5.00	Est. based on OAP1 testing
➢ Optical elements							9.90	Est. based on tech dev program

Legend: *Requirement* *Margin* *RSS Prediction* *Allocation*

SXT FMA Requirements

SXT FMA Performance Requirements		Trace to Top-Level Mission Requirements
Bandpass	0.25 to 10 keV	Allocation of mission bandpass to SXT
Effective area (per mirror) @0.25 keV @1.25 keV @6 keV	8,826 cm^2 8,421 cm^2 1,722 cm^2	Provides 33,000 cm^2 at 1 keV and 6,900 cm2 at 6 keV for the mission. Allows effective area losses due to detector efficiency, etc., to achieve TLRD baseline requirement per error budget summarized in Table 1-2.
Angular resolution	12.5 arcsec HPD	Error budget allocation to mirror that allows telescope system to achieve requirement of 15 arcsec with 4 arcsec margin combined by RSS (Table 1-3).
Field of view	2.5 arcmin	Exceeds instrument FOV; defined by detector FOV
Derived Requirements: SXT Mirror		**Derivation**
Diameter	1.6 m	To meet mission area requirements with 4 mirrors
Focal length	10 m.	Consistent with grazing angle requirements for 1.6 m diameter mirror.
Axial length	<70 cm	To fit within envelope and meet fabrication considerations
Operating temperature	20±1° C nominal	Range is per allocation from SXT angular resolution error budget (Table 1-3); minimizes angular distortions imposed by temperature change to components. Operating temperature is determined by optics assembly temperature
Mass	642 kg	Current engineering estimate
Derived Requirements: SXT Grating: See Table 1-3		
Derived Requirements: Thermal Pre/Post collimators		
Temperature gradient	1° C across diameter 1° C axial	Allocation from SXT angular resolution error budget (Table 1-3); minimizes angular distortions imposed by temperature gradients
Mass	47 kg	Current engineering estimate

RGS System Level Requirements

RGS Performance Requirements		Trace to Mission Top-Level Requirements
Bandpass	0.25-2.0 keV (6 to 50 A)	In combination with XMS, meets spectral resolution rqmts over the 0.25 – 10 keV bandpass. 1 to 2 keV used for calibration with XMS
Spectral resolving power,R (?/??)	$\geq$300 below 1 keV	Meets TLRD baseline requirement for R
Effective Area @0.25 keV @0.6 keV @1.25 keV	 250 cm^2 625 cm^2 175 cm^2	Flowdown from mission baseline effective area requirement

RGA Requirements

Derived RGS Grating Array Requirements		Derivation
Grating efficiency: @0.25 keV (1st Order) @0.6 keV (1st Order) @1.25 keV (2nd Order)	 >0.14 >0.22 >0.06	Flowdown from area requirements. Theoretical efficiency with 50% margin. Met with 40% margin when measured efficiencies for anisotropically etched grating test ruling are used
Interception factor	0.57	Fraction of X-rays entering RGA intercepted by gratings and dispersed in the various orders. Flowdown from area requirements
Straight-through factor	0.38	See Inteception factor (above)
Grating goove parameters a: incidence angle ?: graze angle d: groove spacing	 a = 1.61 deg. ? = 2.21 deg. 1/d = 407 mm^{-1}	Given 15" HPD telescope, and requiring = ?/?? 400 at blaze (blaze = 0.605 deg. reflectivity is optimized there using scalar diffraction theory.
Grating flatness	≤2 arcsec FWHM	Grating error budget flowdown for spectral resolution. Combined with alignment error, allows broadening of the line spread function core by no more than 30% and SXT mirror dominates
Grating to grating alignment	≤2 arcsec FWHM	See grating flatness item (above)
Mass	50 kg	Current engineering estimate

RFC Requirements

Derived RGS Focal Plane Camera Requirements		Derivation
Quantum Efficiency @0.25 keV @0.6 keV @1.25 keV	 >0.86 >0.93 >0.98	Flowdown from area requirements
Energy Resolution at 250 eV	> 90% events within 100 eV band	Required to separate spectra from overlapping orders. The requirement is met with 20% margin by state-of-the-art (ACIS-S) BI CCD's
Optical Blocking Filter -Visible light rejection	 $>10^6$	Optical light rejection to avoid CCD pulse height confusion
X-ray transmission @0.25 keV @1.25 keV	 >0.8 >0.98	Flowdown from area requirements in conjunction with grating efficiency meets the top-level area requirements
Optical starlight rejection	≤1 electron/pixel/readout for 10 magnitude star	Joint requirement on pre-collimator, SXT straylight performance, and SRC CCD optical blocking filter performance
Pixel size	24 microns	Required to critically sample the Point Respose Function
SRC number of pixels, dispersion direction	1.3 X 104	Required to cover the dispersed instrument bandpass (0.25 to 2 keV), given above pixel size and SXT focal length. (1024 pixels x 13 CCDs)
SRC number of pixels, cross-dispersion direction	512	Required to provide adequate areas to enable background subtraction
ZOC CCD format	1024 X 1024	Identical to SRC chips to minimize costs
Frame readout rate	2 second integration time per frame	< 50% pileup in central CCD pixel for bright source limit, assuming 20% flux in single emission line
Operating temperature	-60° C to -80° C	Reduces hot and flickering pixels
Mass	33 kg	Current engineering estimate

Technology Development

- Updated Technology Roadmaps to achieve TRL 6
- Defined Technology Gates:
  - Subsets of TRL demonstrations defined in the TRIP report and
  - Represent significant improvements in performance or scale
- Summarized Technology Development milestones, including goals of each technology demonstration stage for each technology

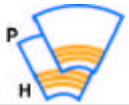
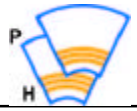
Technology Development Roadmap Summary

System	Technology	Heritage	Required Improvement	Req't	Subsystem Technology Readiness Level by Fiscal Year				
					1998	Current	2004	2005	2006
FMA	SXT Mirror	Astro-E/E2, BBXRT, ASCA	Angular resolution	12.5 arcsec	TRL 2	TRL 3-4	TRL 4	TRL5	TRL 6
		XMM-Newton	Larger diameter	1.6 m					
RGS	Gratings (RGA)	XMM-Newton, Chandra	Low mass	0.2g/cm^2	TRL 3	TRL 3	TRL 5		TRL 6
			Mass production	25/day					
	CCD Detector (RFC)	Chandra, ASCA	Production yield	20%	TRL 2	TRL3	TRL 4	TRL 6	
			Event drive						
XMS	Microcalorimeter	Astro-E/E2	Larger array	32 x 32 pixels	TRL 3	TRL 4	TRL 5	TRL 6	
			Energy resolution	4 eV					
	ADR	Astro-E/E2 HAWC, XQC	Warmer sink	6 K	TRL 3	TRL 4		TRL 5	TRL 6
			Cont. operations						
	Cryocooler	HST, TES, AIRS	Lower temperature	6 K	TRL 3	TRL 4		TRL 5	TRL 6
HXT	HXT Mirrors	HEFT, InFOCµS	Angular resolution	60 arcsec	TRL 3	TRL 4	TRL 5	TRL 6	
	HXT Detectors	HEFT, Swift	Low energy response	6 keV	TRL 3	TRL 4-6	TRL 5	TRL 6	

Technology Gates

System	Technology	Performance Parameter	State-of-the-Art	Current	Technology Gates			Nominal Flight Requirement
					2004	2005	2006	
SXT FMA	Mirrors	Angular Resolution (HPD)	80 arcsec	<15 arcsec (reflector only)	12.5 arcsec	12.5 arcsec		12.5 arcsec
		Diameter	40 cm	20 cm	50 cm	160 cm		160 cm
RGS	Gratings (RGA)	Mass/unit area	0.6g/cm^2	—	0.2g/cm^2		0.2g/cm^2	0.2g/cm^2
		Groove density/variation	645 lines/mm / 7%	500 lines/mm / 0%	N/A		407 lines/mm/5%	407 lines/mm/5%
	CCD	Quantum Efficiency	15%	25%		>80%		86%
XMS	Microcalorimeter	Array Size	32 pixels	25 pixel array 4 pixel readout	64 pixel array 16 pixel readout	1032 pixel array 96 pixel readout		1032 pixel array 1024 pixel readout
		Energy Resolution	4.8 eV at 6 keV	10 eV at 6 keV		4 eVat 6 keV		4 eV at 6 keV
	ADR	Cold/Hot end	50mK/1.1K	50mK/4K		50mK/6K		50mK/6K
		Operating mode	Periodic	Continuous		Continuous		Continuous
	Cryocooler	Cooling power	1.5 mW at 55K	0 mW at 5.4K		20 mW at 6K		20 mW at 6K
HXT	Mirrors	Obscuration throughput	40%	60%		75%		75%
	Detectors	Low Energy Threshold	~17 keV	~17 keV		6 keV		6 keV

SXT FMA Technology Development Roadmap Summary

	Optical Pathfinder Assembly		Engineering Unit	Mass Alignment Pathfinder	Prototype	
	OAP #1	OAP #2				
Configuration						
Module Type	Inner	Inner	Inner	Inner	Outer	Wedge (2 Outer & 1 Inner)
Housing Material	Aluminum	Titanium	Composite	Composite	Composite	Composite
Focal Length	8.4 m	8.4 m	8.4 m	8.4 m	10.0 m	10.0 m
Reflector Length (P&H)	2 x 20 cm	2 x 20 cm	2 x 20 cm	2 x 20 cm	2 x 20-30 cm	2 x 20-30 cm
Nominal Reflector Diameter(s)	50 cm	50 cm	50 cm±	50 cm±	160 cm 120 cm± 100 cm	160 cm±40 cm± 120 cm± 100 cm±
Goals	▪ Align 1 reflector pair (P&H) ▪ Evaluate mirror assembly design, alignment and metrology	▪ Align 1 reflector pair ▪ Evaluate reflector ▪ Evaluate mirror bonding	▪ Align up to 3 reflector pairs to achieve <12.5 arcsec ▪ Eval. assembly gravity sag ▪ X-ray and environmental test ▪ Evaluate composite housing	▪ Align 3 reflector pairs ▪ Evaluate tooling and alignment techniques for mass production ▪ X-ray test	▪ Flight-like configuration outer module ▪ Environmental and X-ray test ▪ Largest reflectors	▪ Demonstrate largest and smallest diameter reflectors ▪ Demonstrate module to module alignment ▪ Environmental and X-ray test
TRL	TRL 3		TRL 4		TRL 5	TRL 6
Timeframe	Q2 of FY03	Q3 of FY03	Q1 of FY04	Q1 of FY05	Q4 of FY05	Q4 of FY06
Technology Gate			◆		◆	

RGA Technology Development Roadmap Summary

Parameters	State-of-the-Art XMM-Newton	Grating Fab Demo	Large Area Grating	Demo Assembly	Grating Chirp	Grating Module Engineer Unit	Grating Module Flight Unit
Substrate Flatness	<2 arc sec	~30 arc sec	<2 arc sec	<2 arc sec	<2 arc sec	<2 arc sec	<2 arc sec
Grating Size	200 x 100 mm	20 x 20 mm	140 x 100 mm (70% flight size)	200 x 100 mm (nom. flight size)	(200 x 100 mm)	(200 x 100 mm)	(200 x 100 mm)
Grating Mass/Unit Area	0.6g/cm^2	—	—	0.2g/cm^2	—	0.2g/cm^2	0.2g/cm^2
Groove Form	0.7 deg blaze	0.7 deg blaze	0.6 deg blaze	NA	0.6 deg blaze	0.6 deg blaze	0.6 deg blaze
Ruling Density/Variation	646 l/mm / 7%	500 l/mm / NA	407 l/mm / 0%	NA	407 l/mm / 5%	407 l/mm / 5%	407 l/mm / 5%
Groove Fabrication Process	Epoxy multi-gen replication of mechanically ruled master grating	Interference lithography & anisotropic etch Si (111) plane facet	Scanning Beam Interference Lithography (SBIL) Si (111) plane facet	NA	Variable Period (VP) SBIL pattern & anisotropic etch Si (111) plane facet	VPSBIL pattern & anisotropic etch Si (111) plane facet	VPSBIL pattern & anisotropic etch Si (111) plane facet
Ass'y Level & Properties	Gratiing Array	Single grating	Single grating	Module	Single grating	Module	Module
Gratings per Module	182 per array			3 or more gratings		~10 gratings	~10 gratings
Grating-to-Grating Align't	2 arc sec			2 arcsec		2 arcsec	2 arcsec
Other Goals	NA	▪ X-ray test atomically smooth groove facet	▪ X-ray efficiency test large area grating for groove quality and uniformity	▪ Grating substrates fab'd w mass production processes applicable to flight gratings		▪ End-to-end X-ray test of grating module with SXT mirror segment	
				▪ Flight representative module structure		▪ Flight like gratings and modules	
				▪ Verify alignment before/after environmental test		▪ Verify alignment before/after environmental test	
TRL	TRL 9	TRL 3	TRL 4	TRL 5		TRL 6	
Timeframe		Current	Q2 FY04	Q4 FY04	Q3 FY05	Q2 FY06	
Technology Gate				◆		◆	

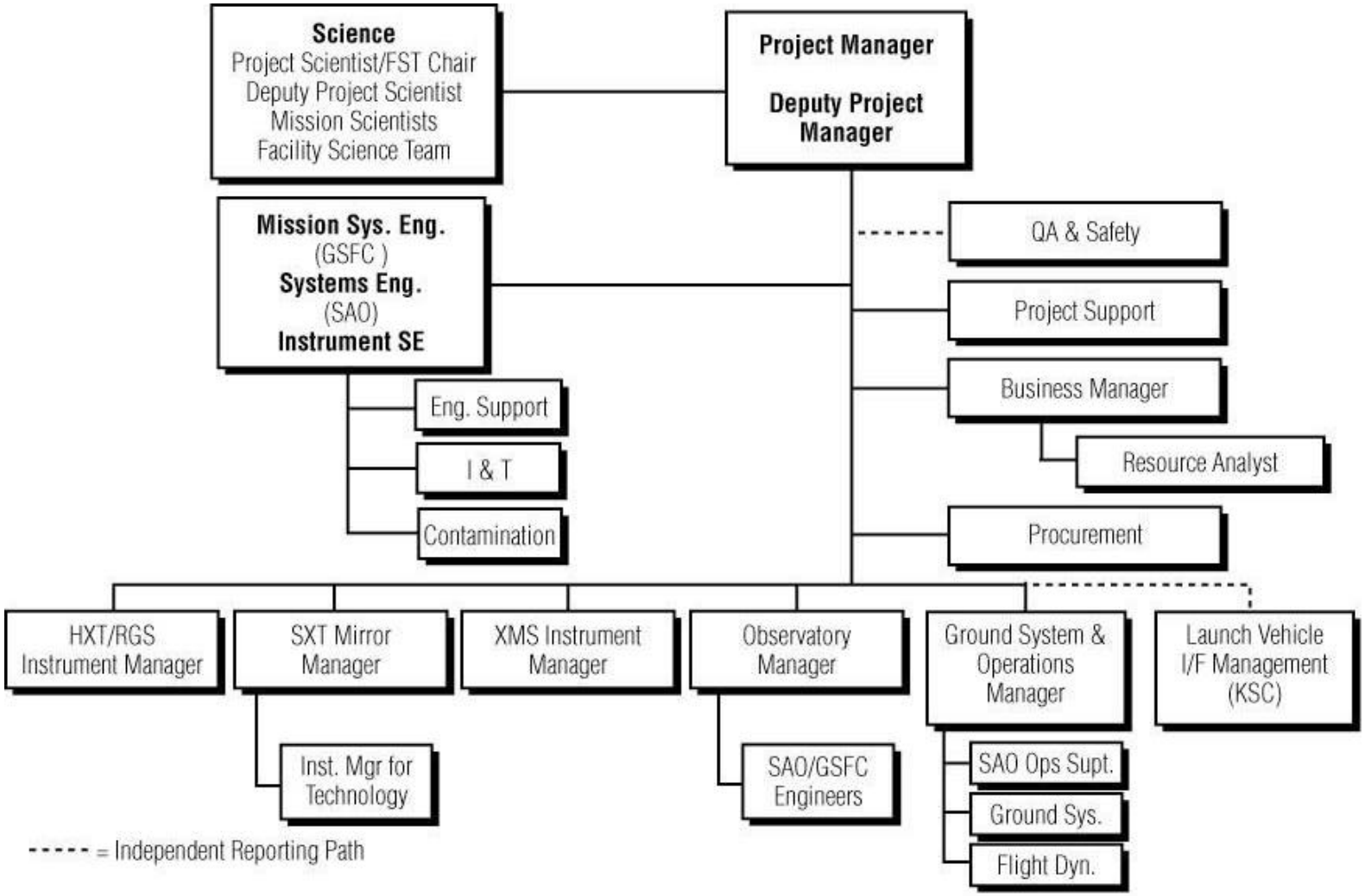
RGS Focalplane Camera (RFC) Technology Roadmap

Parameter	State-of-the-Art Chandra ACIS	Current	ED-CCD Gen1 Lot1	ED-CCD Gen2 Lot1	ED-CCD Gen2 Lot2	ED-CCD Gen2 Lot3	Engineering Unit Focal Plane	Flight Requirements
QE at 0.25 keV								
▪ Bare CCD	0.73	0.8	N/A (FI)	0.8	0.9	0.95	0.95	0.95
▪ CCD+OBF	0.15	0.25	N/A (FI)	0.3	0.8	0.86	0.86	0.86
Device Yield								
▪ FI	0.1	0.8	0.8 est	0.8	0.8	0.8		
▪ BI	0.02	0.25	N/A (FI)	0.25	0.25	0.25		
▪ Net = FI*BI	0.002	0.2		0.2	0.2	0.2		0.2
CCD Frame Rate (Hz)	0.5	2	10	50	50	50	50	50
EDCCD Config		—	FI	FI, BI	FI, BI	BI	BI	BI
Energy Resolution (eV)								
@1.5 keV	130 (S3-BI)	69 (FI)	70(FI) pred	125 (BI)	100 (BI)	100 (BI)	100	100
@0.25 keV	110 (S3-BI)	91 (LTM-BI)	N/A (FI)	125 (BI)	100 (BI)	100 (BI)	100	100
Event Reconstruction	3x3, 5x5	3x3, 5x5	3x3	3x3,5x5	3x3,5x5	3x3,5x5	3x3,5x5	3x3,5x5
Array Format	1024^2		512^2	1024^2	1024^2	1024^2	1024^2	1024^2
Focal Plane Complexity	10 chips	48 chips	1 chip	1 chip	1 chip	1 chip	4 chips	13 chips
Radiation Tests			Y	Y		Y	Y	
Environmental Tests							Y	
Milestone Dates	2Q FY97	3Q FY03	3Q FY03	2Q FY03	1Q Fy05	3Q FY05	4Q FY05	
TRL		TRL3		TRL4			TRL 6	
Technology Gate						◆		

Management, Cost and Schedule

- Organization Structure
- Acquisition Strategies
- Schedules
  - Detailed
  - Critical Paths
- Cost Estimates
  - Grass roots, Industry ROMs, PRICE-H
  - Contingency

Constellation-X Project Organization (Formulation)

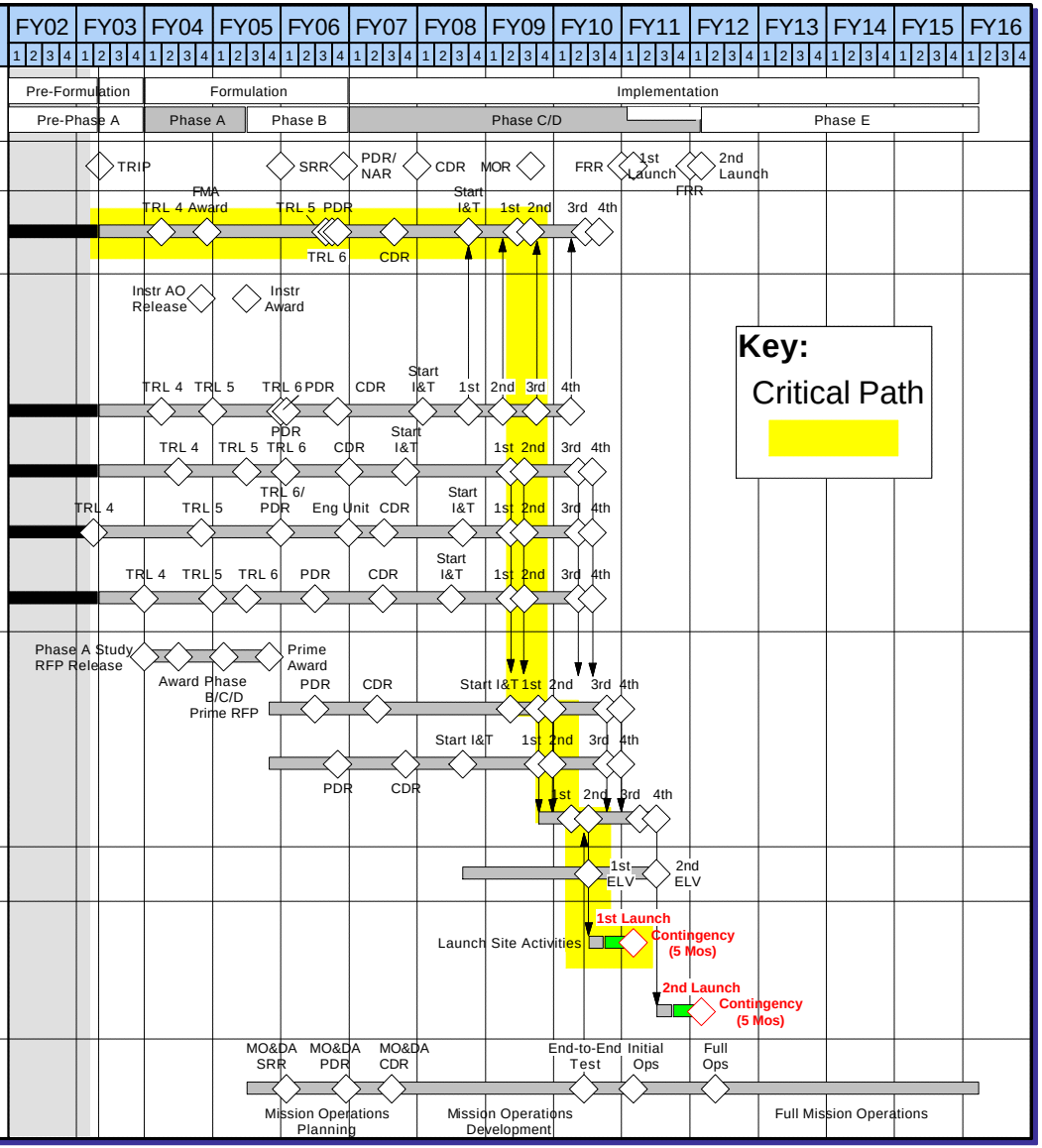


Acquisition Strategy Summary

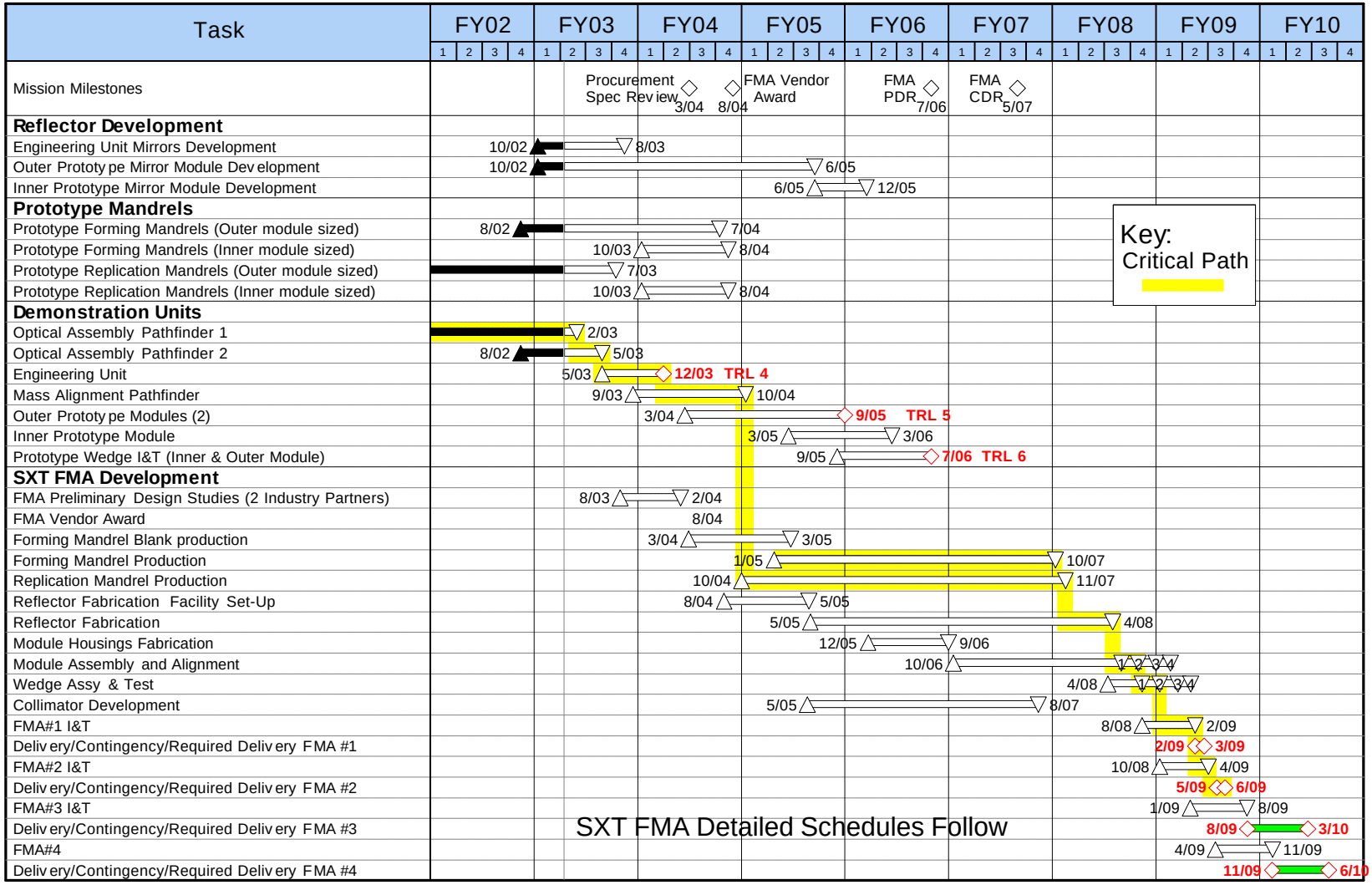
System	Solicitation	Contract Award
Instruments (RGS, XMS, HXT)	Announcement of Opportunity	Phase B start
SXT FMA	RFP	Mid-Phase A
Observatory	RFP	Phase B start
Science and Operations Center (CXSOC)	Sole Source to SAO	Phase B start
Ground Stations	RFP for commercial lease	L – 18 months
Launch Vehicle	KSC procurement	L – 30 months

TRIP Constellation-X Mission Summary Schedule

WBS	Task
	Phases
	Major Reviews & Milestones
1.1, 5.0	**SXT FMA**
1.0, 6.0	**Instruments**
1.3, 6.2	**RGS**
	RGA
	RFC
1.2, 6.1	***XMS***
1.4, 6.3	***HXT***
7.0	**Observatory**
7.2	*Telescope Module*
7.3	*Spacecraft Bus*
7.4	*Observatory I&T*
9.0	**Atlas V ELV**
8.0	**Launch Site Activities & Contingency**
10.0	**MO&DA**



SXT Flight Mirror Assembly (FMA) Development Schedule



TRIP Review Panel Report Summary—April 22, 2003

- *GSFC and SAO are a Strong Team, Experienced in X-Ray Astronomy Missions*
- *The Mission has Strong Support from GSFC Management*
- *The Project Benefits from a Rich Heritage While at the same Time Pushing the Envelope in Several Key Technology Areas*
- *The Schedule and Budget Reserves are Low, Espectialy Early Year Funding*
- *The Review Panel Feels that with Added Budget and Schedule Reserves, Con-X has a High Likelihood of Reaching the Launch Pad Successfully and on Time*

TRIP Highlights Summary and Conclusions

- Generation of TRIP report valuable
  - Overall mission planning taken to next level of detail
  - Report itself is handy reference
- Independent TRIP Review assessment validates mission concept and plans; identifies areas to further reduce risk
- Most of work for TRIP is applicable to stretched out schedule
- Project is positioned to enter into Phase A